Cryptography and Network Security

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# Chapter 14

# Entity Authentication

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## Objectives

- To distinguish between message authentication and entity authentication
- To define witnesses used for identification
- To discuss some methods of entity authentication using a password
- To introduce some challenge-response protocols for entity authentication
- To introduce some zero-knowledge protocols for entity authentication
- To define biometrics and distinguish between physiological and behavioral techniques

# 14-1 INTRODUCTION

***Entity authentication is a technique designed to let one party prove the identity of another party. An entity can be a person, a process, a client, or a server. The entity whose identity needs to be proved is called the claimant; the party that tries to prove the identity of the claimant is called the verifier.***

***Topics discussed in this section:***

**14.1.1 Data-Origin Versus Entity Authentication**
**14.1.2 Verification Categories**
**14.1.3 Entity Authentication and Key Management**

## *14.1.1 Data-Origin Versus Entity Authentication*

***There are two differences between message authentication (data-origin authentication), discussed in Chapter 13, and entity authentication, discussed in this chapter.***

1) ***Message authentication might not happen in real time; entity authentication does.***
2) ***Message authentication simply authenticates one message; the process needs to be repeated for each new message. Entity authentication authenticates the claimant for the entire duration of a session.***

# 14.1.2 Verification Categories

***Something known***

***Something possessed***

***Something inherent***

## *14.1.3 Entity Authentication and Key Management*

***This chapter discusses entity authentication. The next chapter discusses key managment.***

# 14-2 PASSWORDS

***The simplest and oldest method of entity authentication is the password-based authentication, where the password is something that the claimant knows.***

***Topics discussed in this section:***

**14.2.1 Fixed Password**

**14.2.2 One-Time Password**

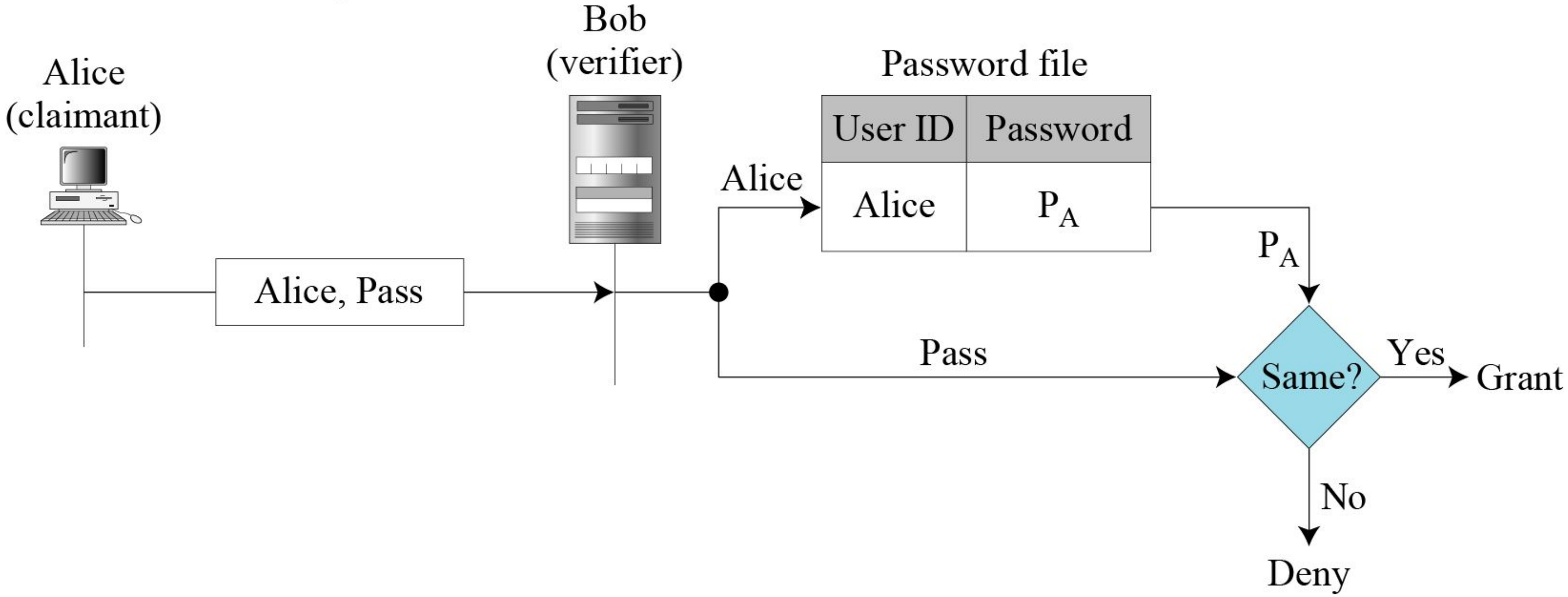
# 14.2.1 Fixed Password

## First Approach

**Figure 14.1** ***User ID and password file***

$P_A$: Alice’s stored password

Pass: Password sent by claimant

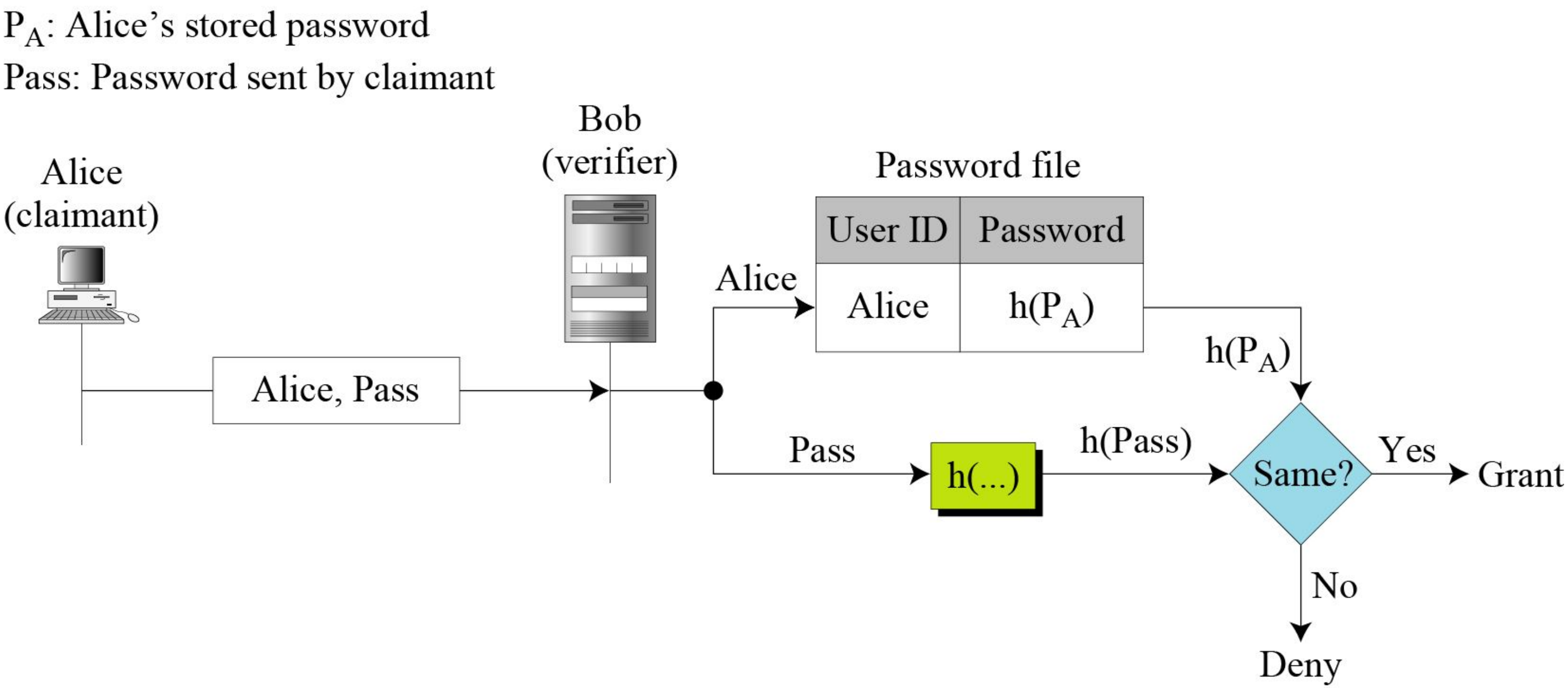


| User ID | Password |
|---|---|
| Alice | $P_A$ |

# *14.2.1 Continued*

## *Second Approach*

**Figure 14.2** ***Hashing the password***



$P_A$: Alice's stored password

Pass: Password sent by claimant

Password file

| User ID | Password |
|---|---|
| Alice | $h(P_A)$ |

# 14.2.1 Continued

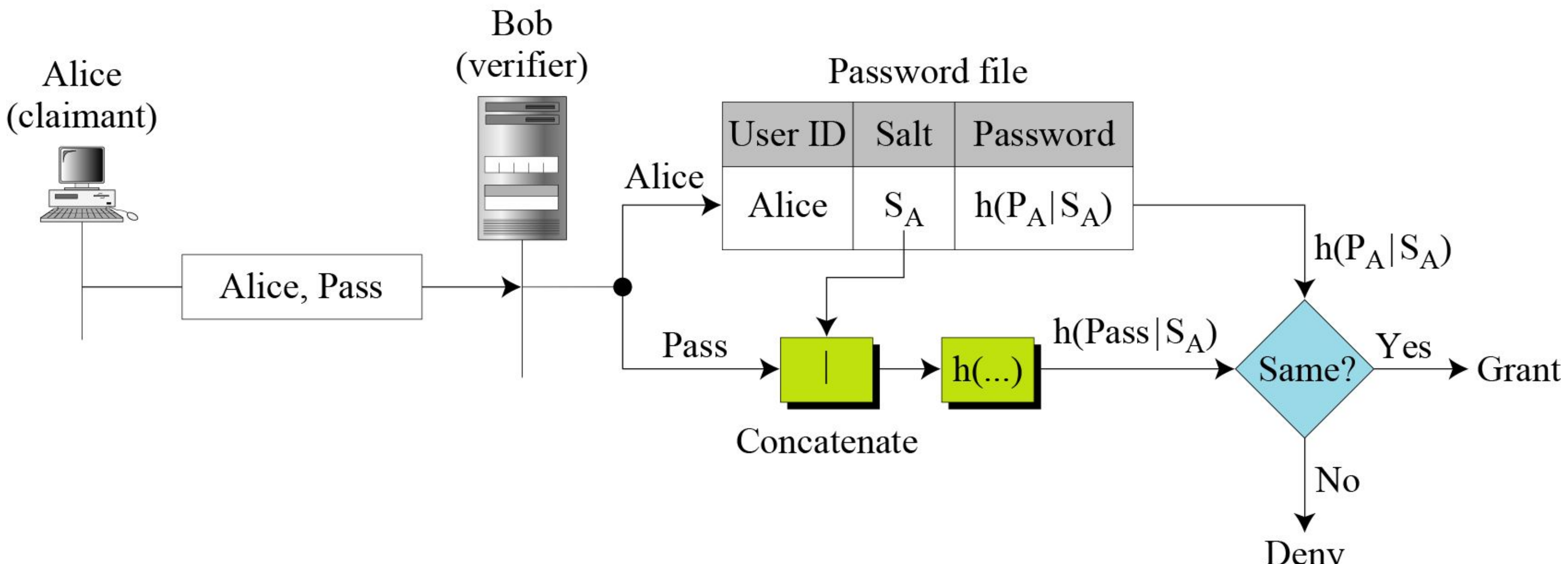
## Third Approach

**Figure 14.3** ***Salting the password***

$P_A$: Alice’s password

$S_A$: Alice’s salt

Pass: Password sent by claimant



Password file

| User ID | Salt | Password |
|---|---|---|
| Alice | $S_A$ | $h(P_A \mid S_A)$ |

# *14.2.1 Continued*

## *Fourth Approach*

***In the fourth approach, two identification techniques are combined. A good example of this type of authentication is the use of an ATM card with a PIN (personal identification number).***

# *14.2.2 One-Time Password*

## *First Approach*

***In the first approach, the user and the system agree upon a list of passwords.***

## *Second Approach*

***In the second approach, the user and the system agree to sequentially update the password.***

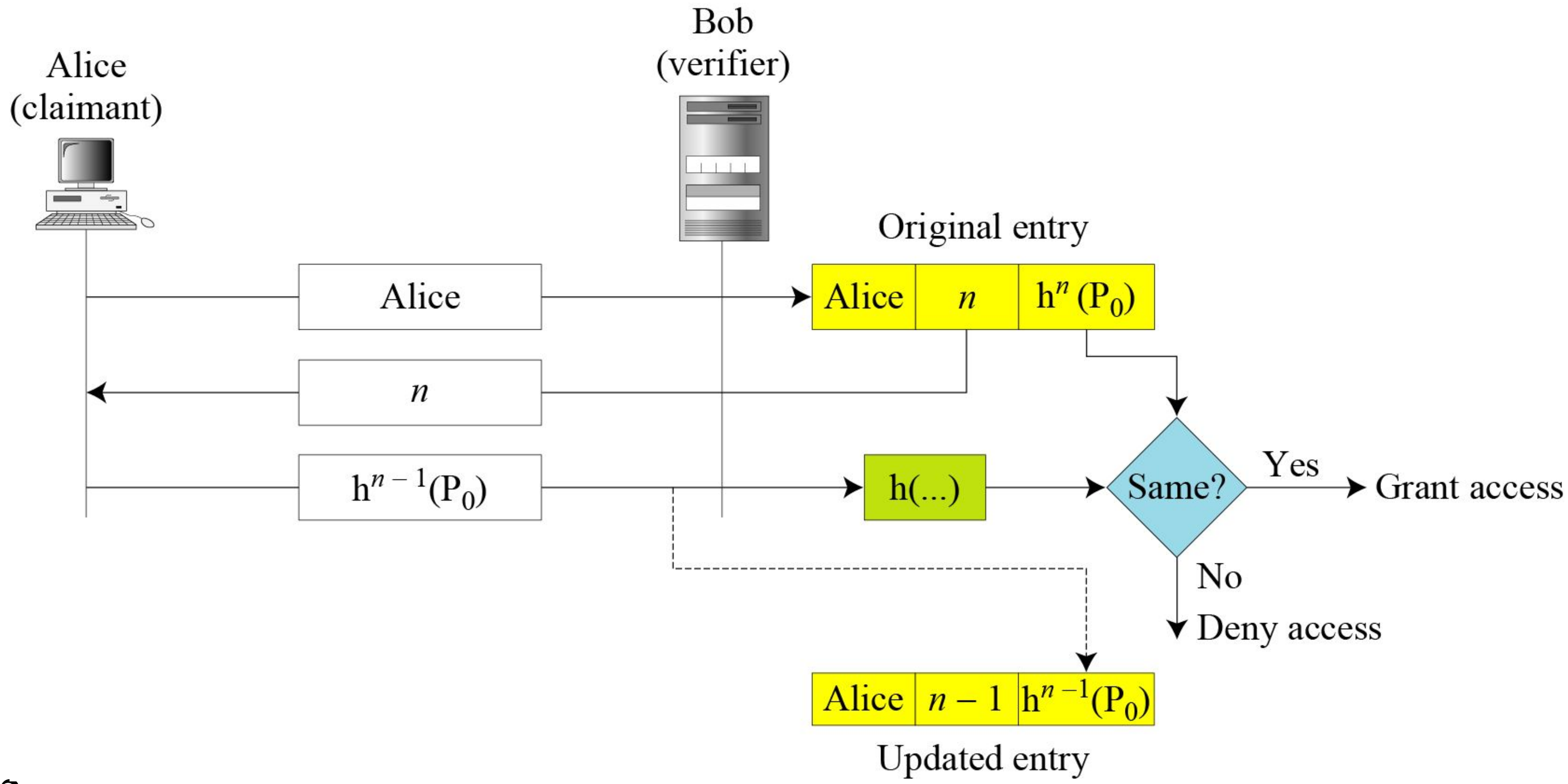
## *Third Approach*

***In the third approach, the user and the system create a sequentially updated password using a hash function.***

$$\mathrm{h}^{n}(x) = \mathrm{h}(\mathrm{h}^{n-1}(x)) \quad \mathrm{h}^{n-1}(x) = \mathrm{h}(\mathrm{h}^{n-2}(x)) \quad \ldots \quad \mathrm{h}^{2}(x) = \mathrm{h}(\mathrm{h}(x)) \qquad \mathrm{h}^{1}(x) = \mathrm{h}(x)$$

# 14.2.2 Continued

**Figure 14.4** ***Lamport one-time password***



# 14-3 CHALLENGE-RESPONSE

***In password authentication, the claimant proves her identity by demonstrating that she knows a secret, the password. In challenge-response authentication, the claimant proves that she knows a secret without sending it.***

***Topics discussed in this section:***

**14.3.1 Using a Symmetric-Key Cipher**
**14.3.2 Using Keyed-Hash Functions**
**14.3.3 Using an Asymmetric-Key Cipher**
**14.3.4 Using Digital Signature**

# 14-3 Continue

*Note*

**In challenge-response authentication, the claimant proves that she knows a secret without sending it to the verifier.**

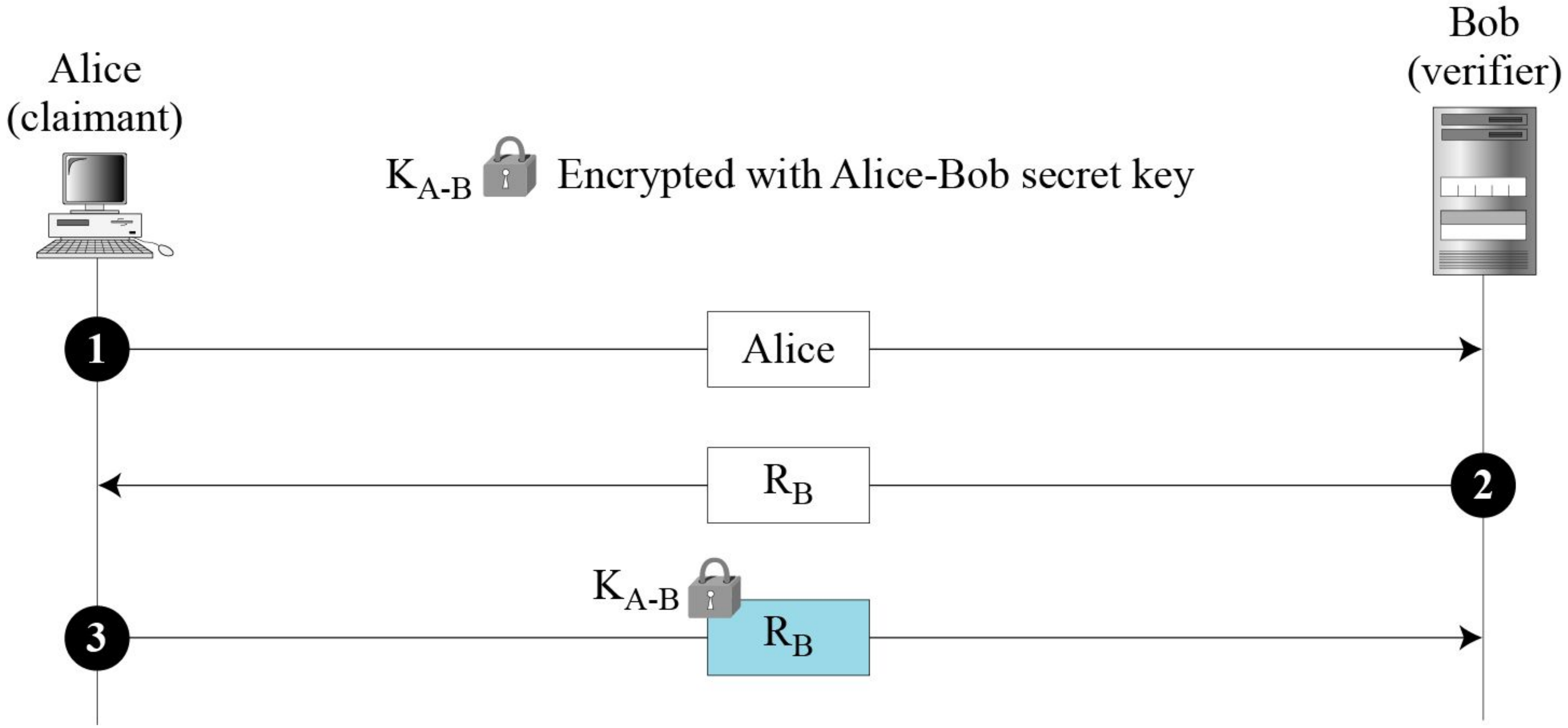
*Note*

**The challenge is a time-varying value sent by the verifier; the response is the result of a function applied on the challenge.**

# 14.3.1 Using a Symmetric-Key Cipher

## First Approach

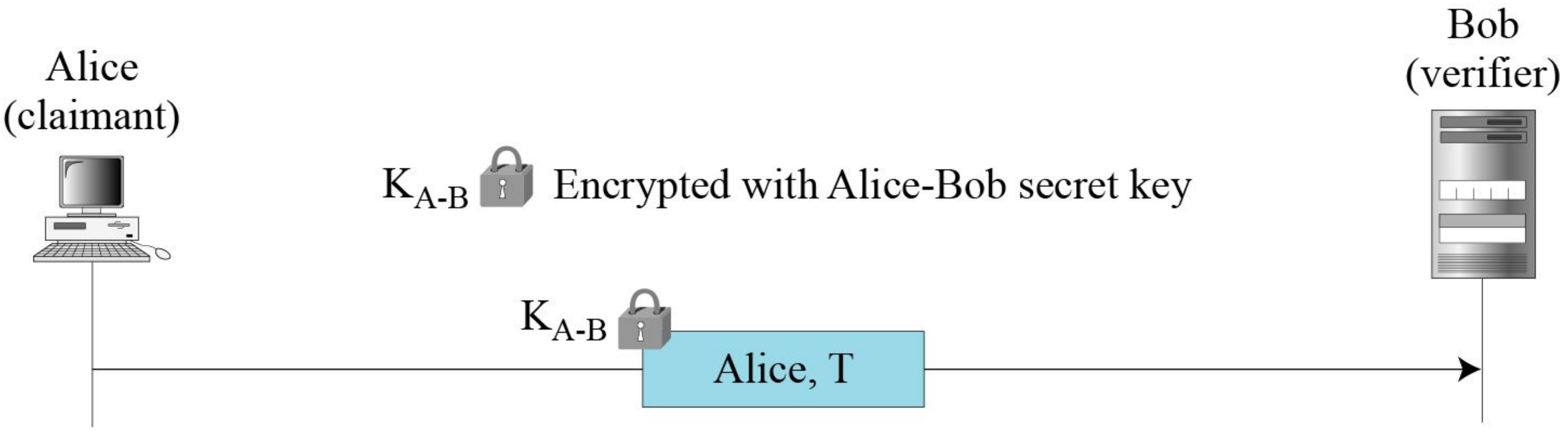
**Figure 14.5** *Nonce challenge*



# 14.3.1 Continued

## Second Approach

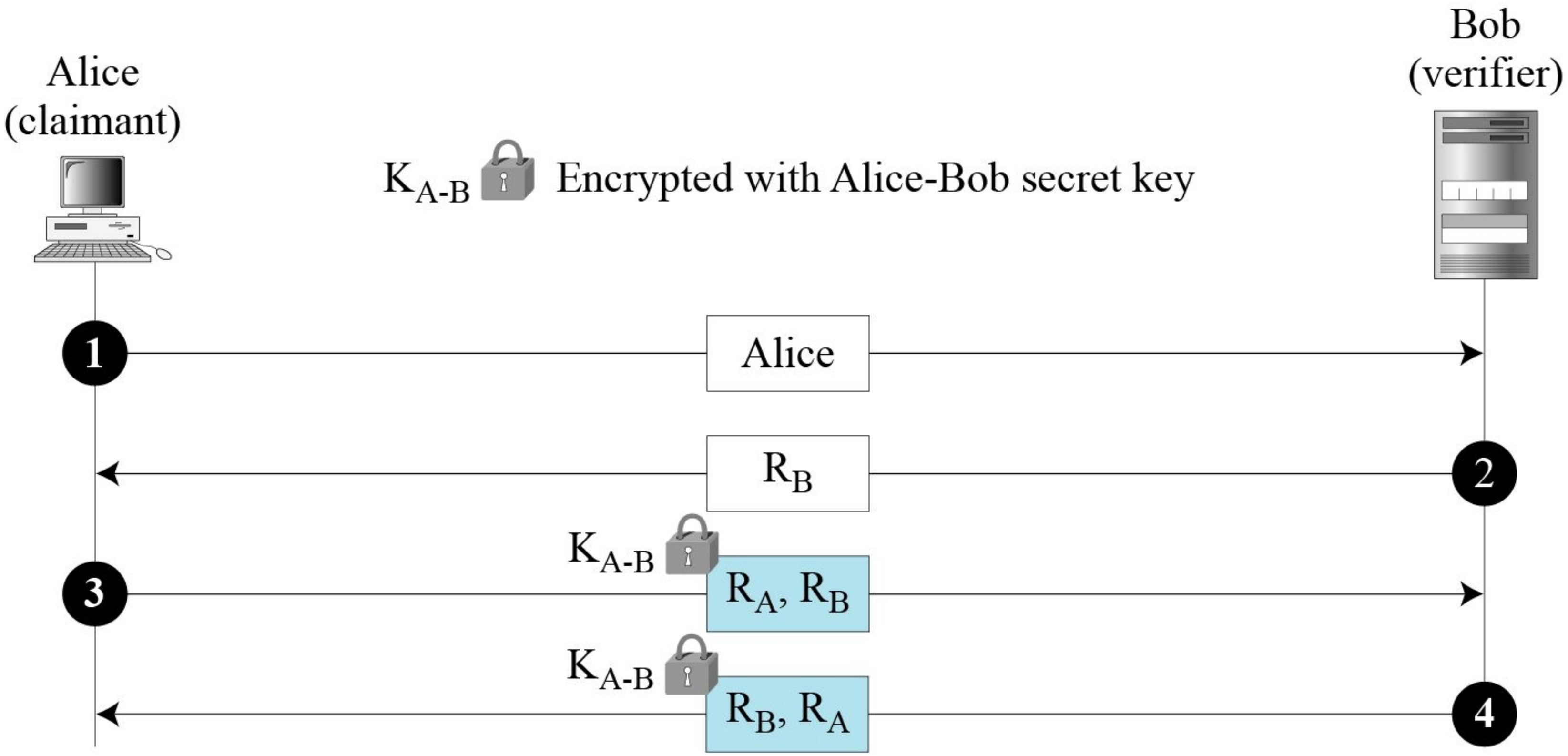
**Figure 14.6** *Timestamp challenge*



# 14.3.1 Continued

*Third Approach*.

**Figure 14.7** ***Bidirectional authentication***



Alice (claimant)

Bob (verifier)

$K_{A\text{-}B}$ Encrypted with Alice-Bob secret key

1 Alice

2 $R_B$

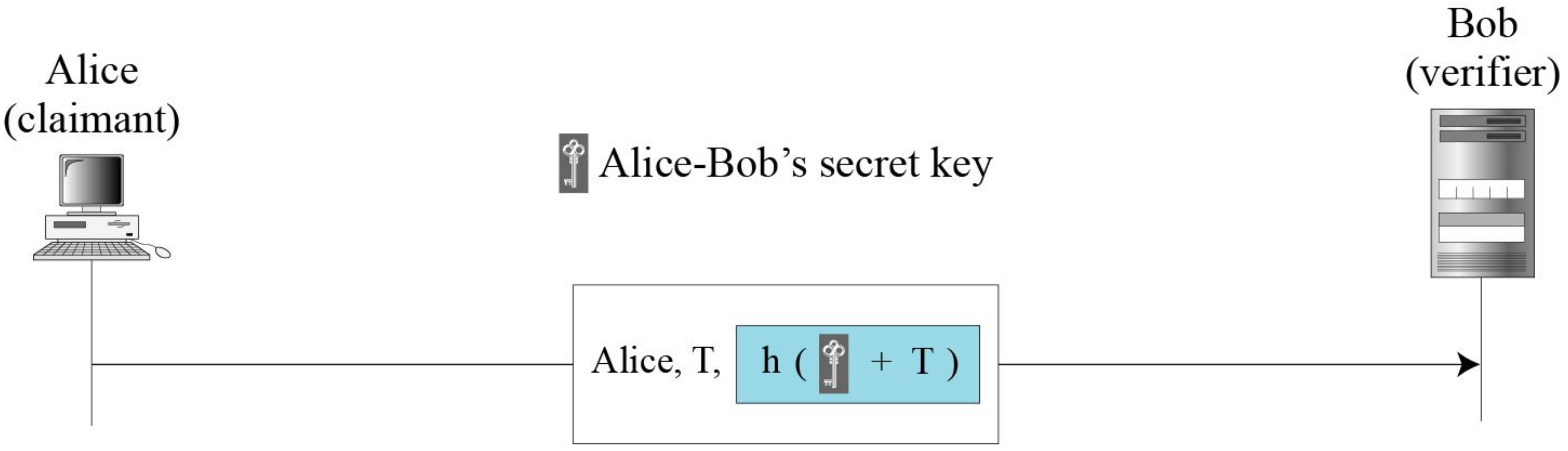
3 $K_{A\text{-}B}$ $R_A, R_B$

4 $K_{A\text{-}B}$ $R_B, R_A$

# 14.3.2 Using Keyed-Hash Functions

***Instead of using encryption/decryption for entity authentication, we can also use a keyed-hash function (MAC).***

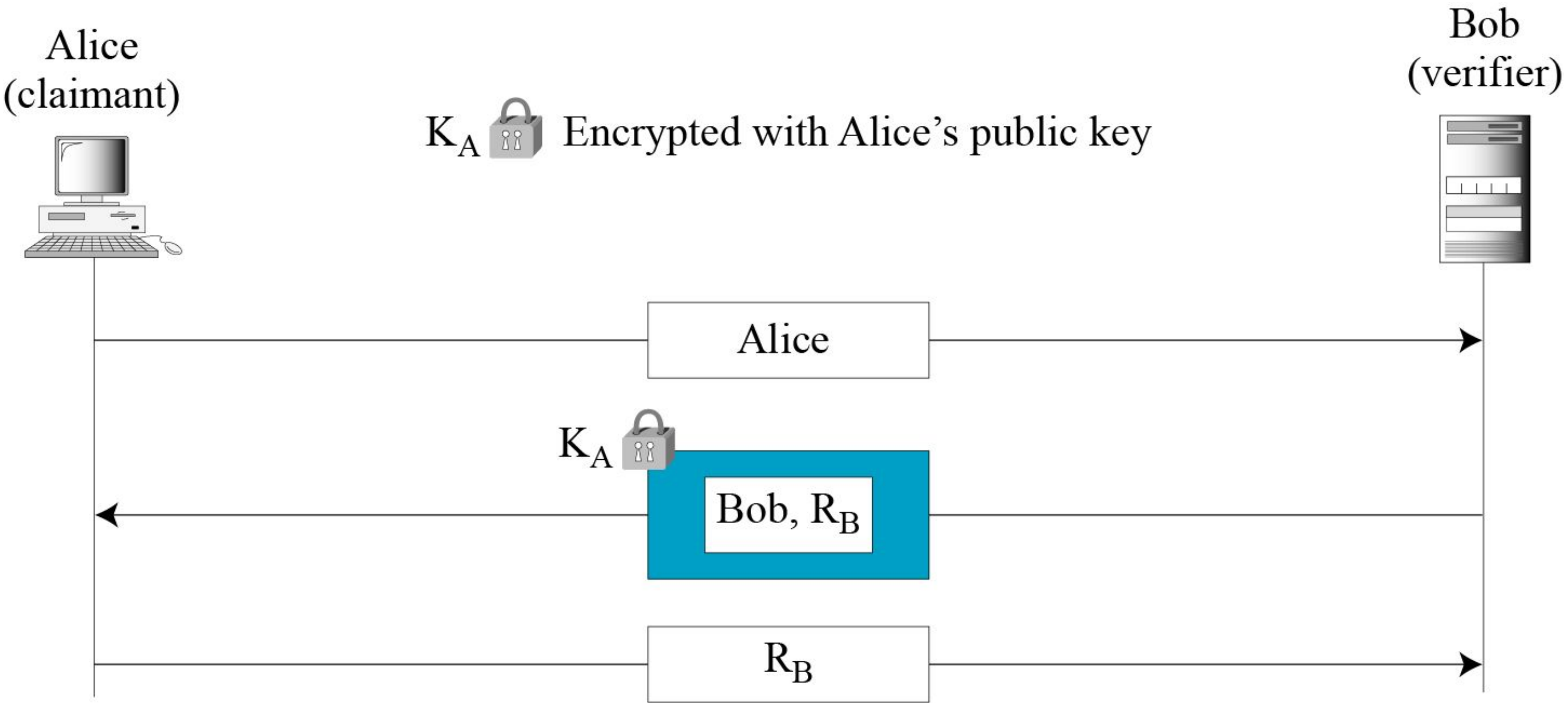
**Figure 14.8** ***Keyed-hash function***



# 14.3.3 Using an Asymmetric-Key Cipher

## *First Approach*

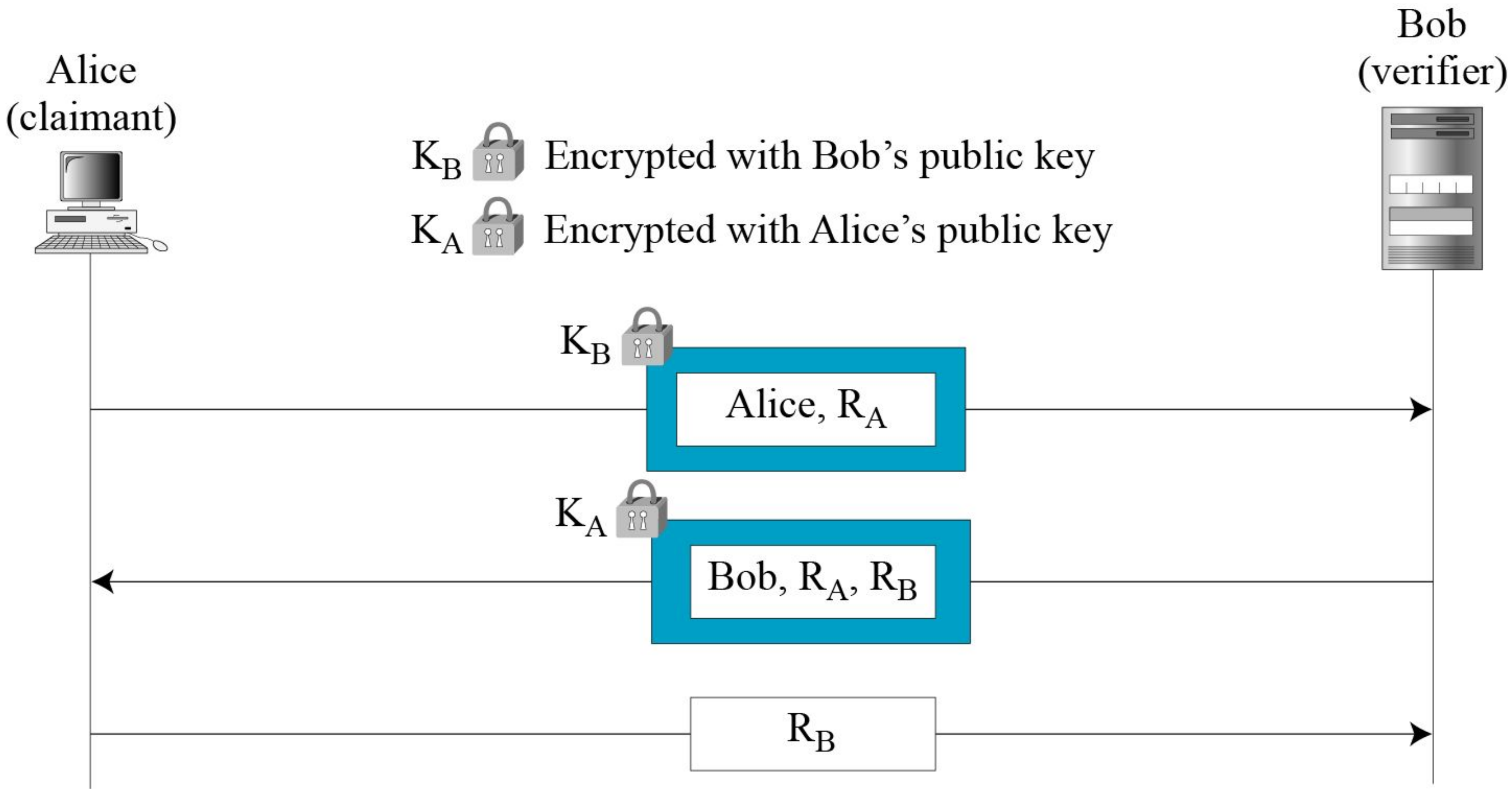
**Figure 14.9** ***Unidirectional, asymmetric-key authentication***



# 14.3.3 Continued

## Second Approach

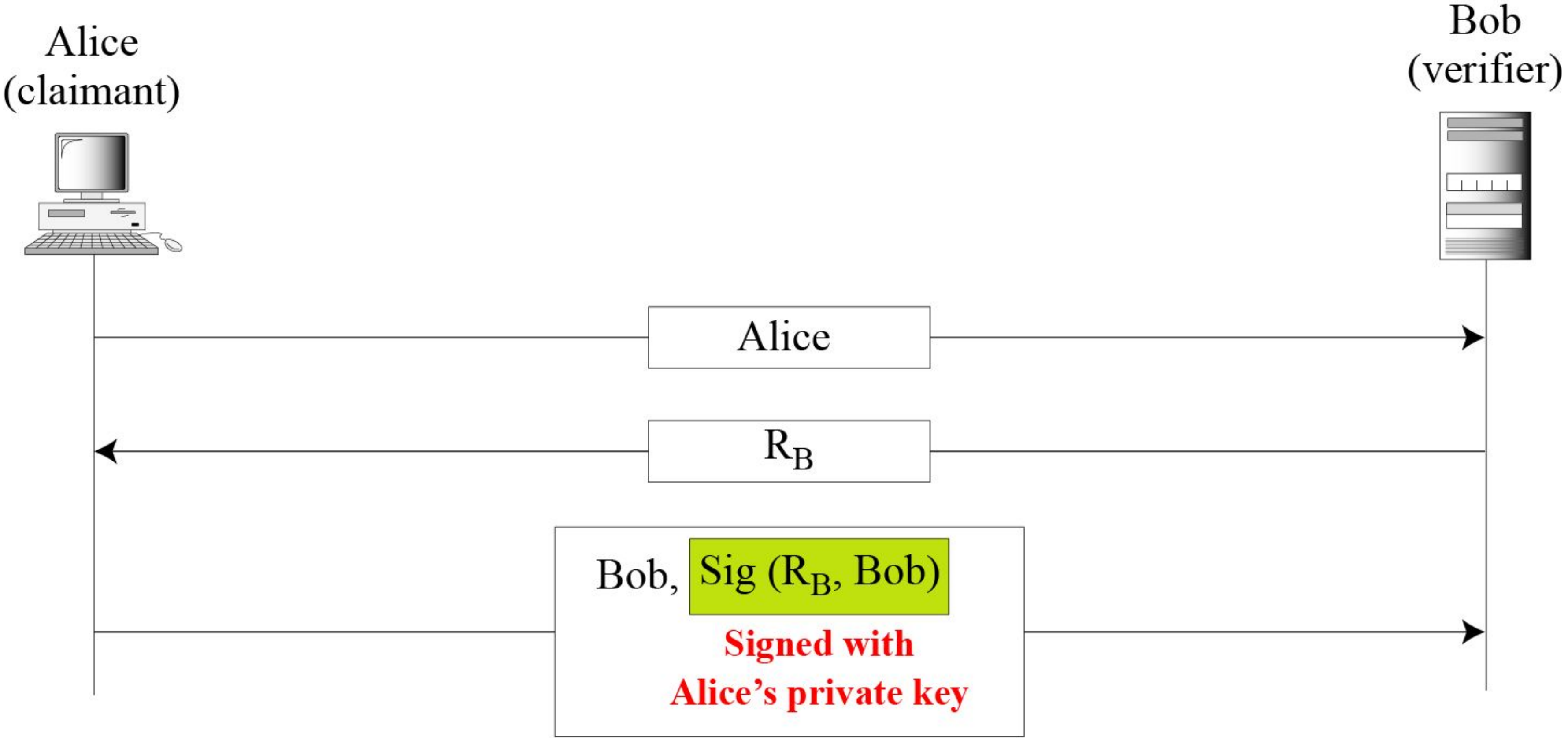
**Figure 14.10** ***Bidirectional, asymmetric-key***


Alice
(claimant)
Bob
(verifier)
$K_B$ Encrypted with Bob's public key
$K_A$ Encrypted with Alice's public key
$K_B$
Alice, $R_A$
$K_A$
Bob, $R_A$, $R_B$
$R_B$

# 14.3.4 Using Digital Signature

## First Approach

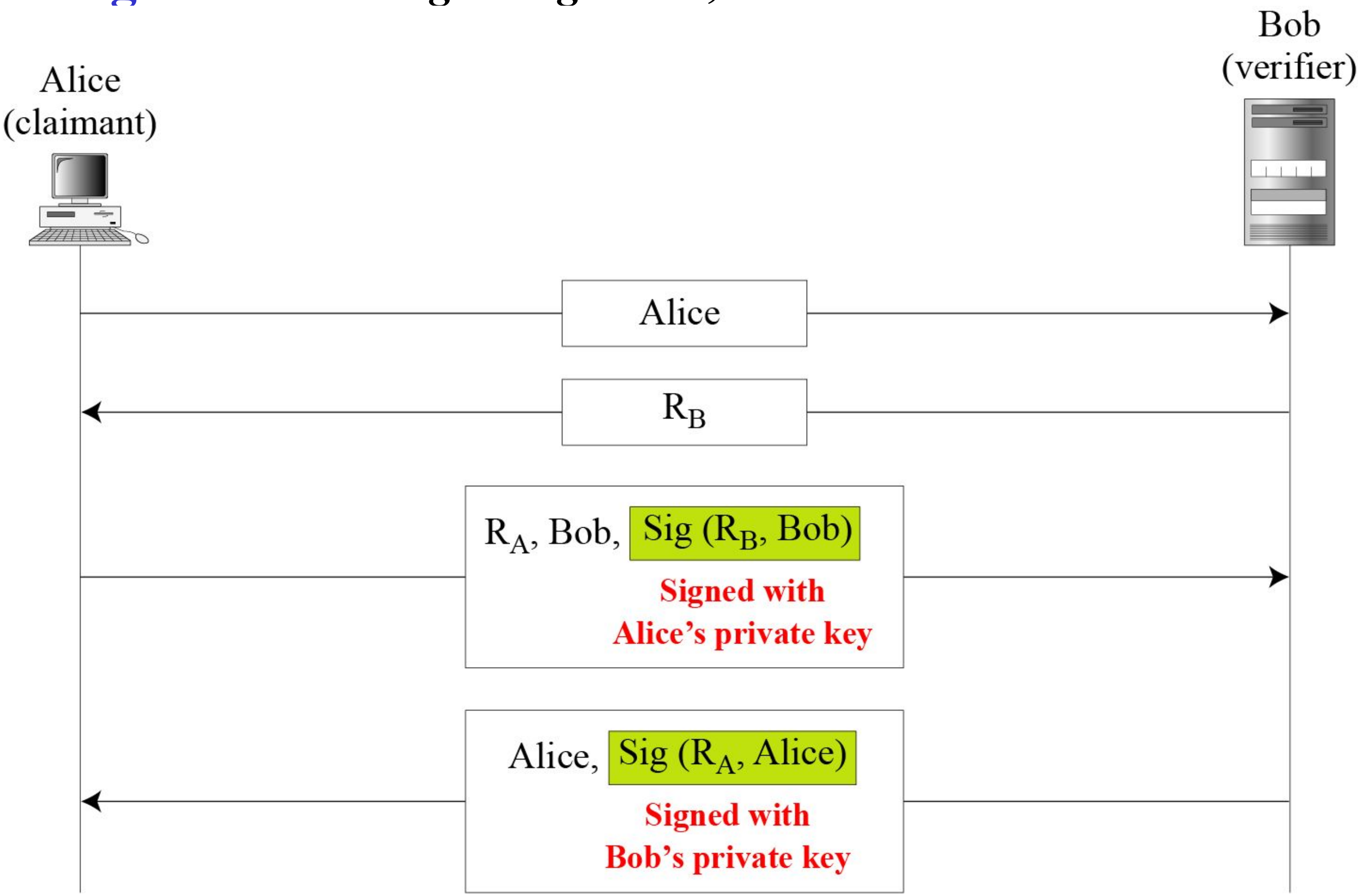
**Figure 14.11** ***Digital signature, unidirectional***



# 14.3.4 Continued

## Second Approach

**Figure 14.12** *Digital signature, bidirectional authentication*



# 14-4 ZERO-KNOWLEDGE

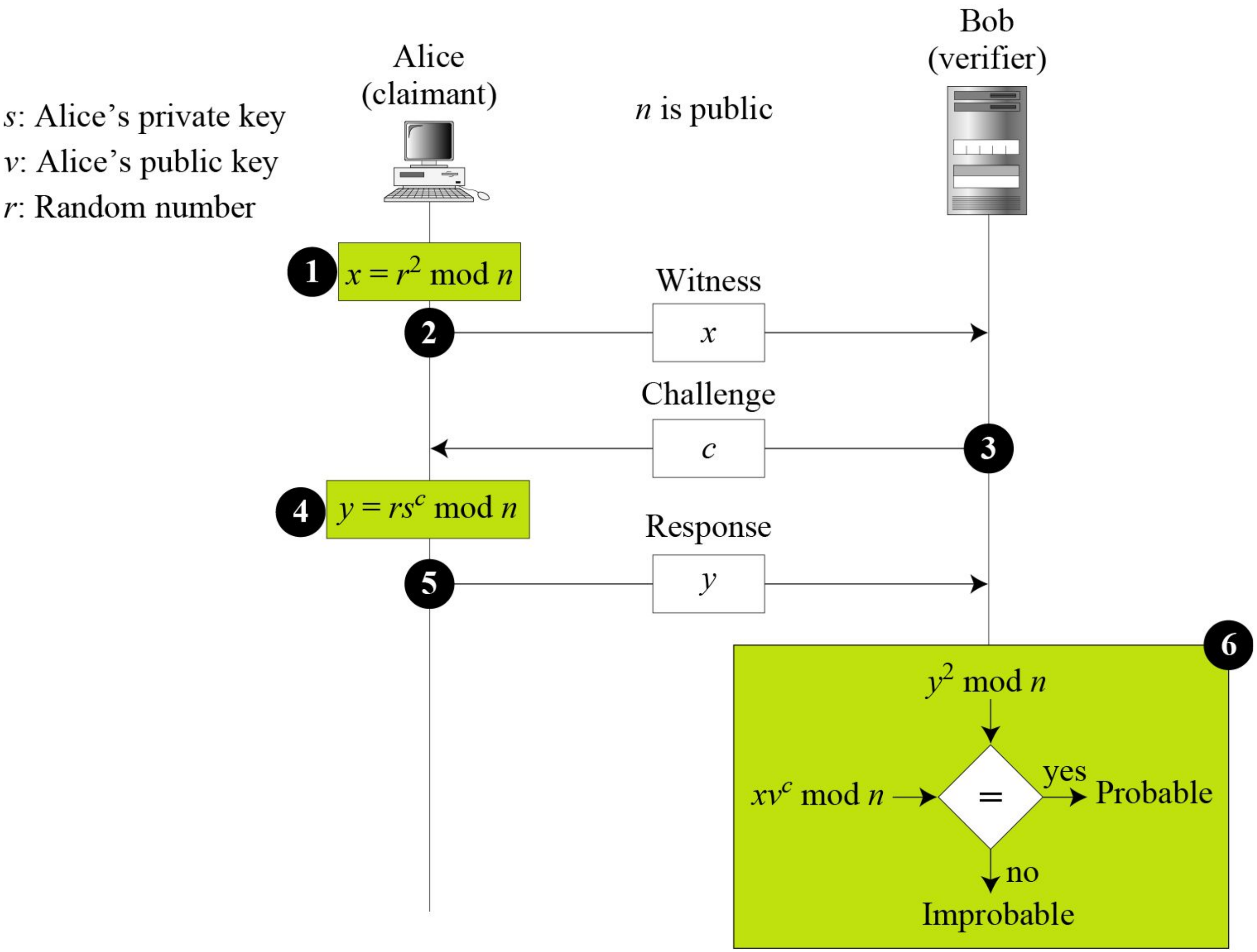
***In zero-knowledge authentication, the claimant does not reveal anything that might endanger the confidentiality of the secret. The claimant proves to the verifier that she knows a secret, without revealing it. The interactions are so designed that they cannot lead to revealing or guessing the secret.***

***Topics discussed in this section:***

**14.4.1 Fiat-Shamir Protocol**
**14.4.2 Feige-Fiat-Shamir Protocol**
**14.4.3 Guillou-Quisquater Protocol**

# 14.4.1 Fiat-Shamir Protocol

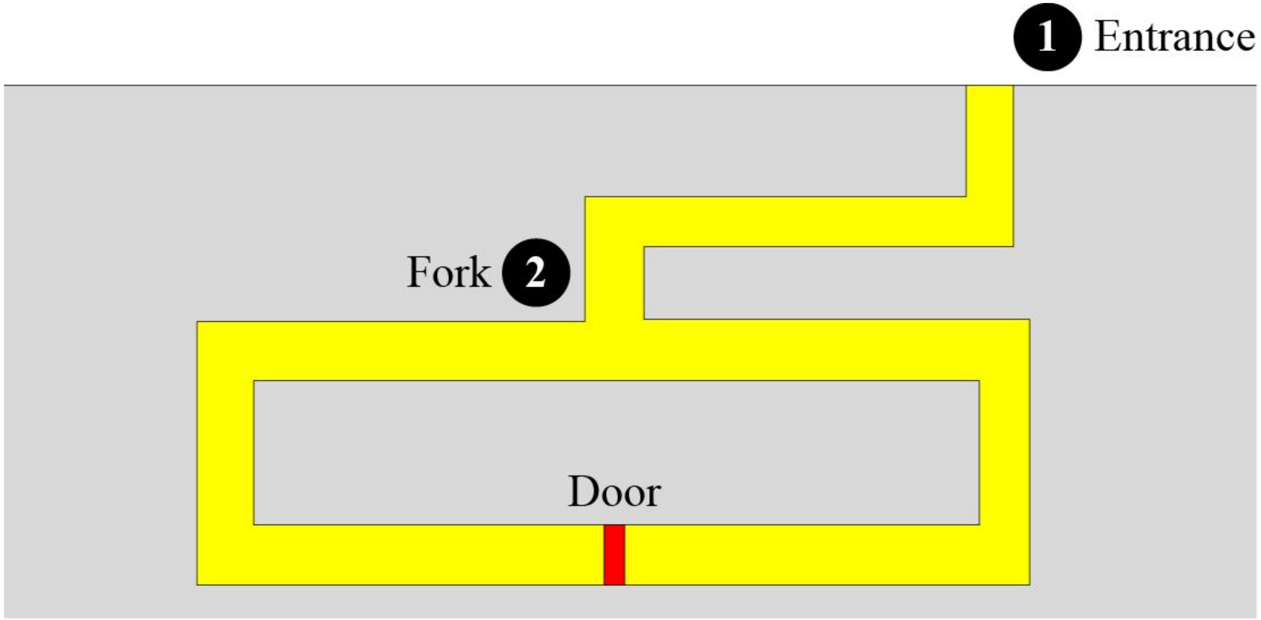
**Figure 14.13** ***Fiat-Shamir protocol***



# *14.4.1 Continued*

## *Cave Example*

**Figure 14.14** ***Cave example***



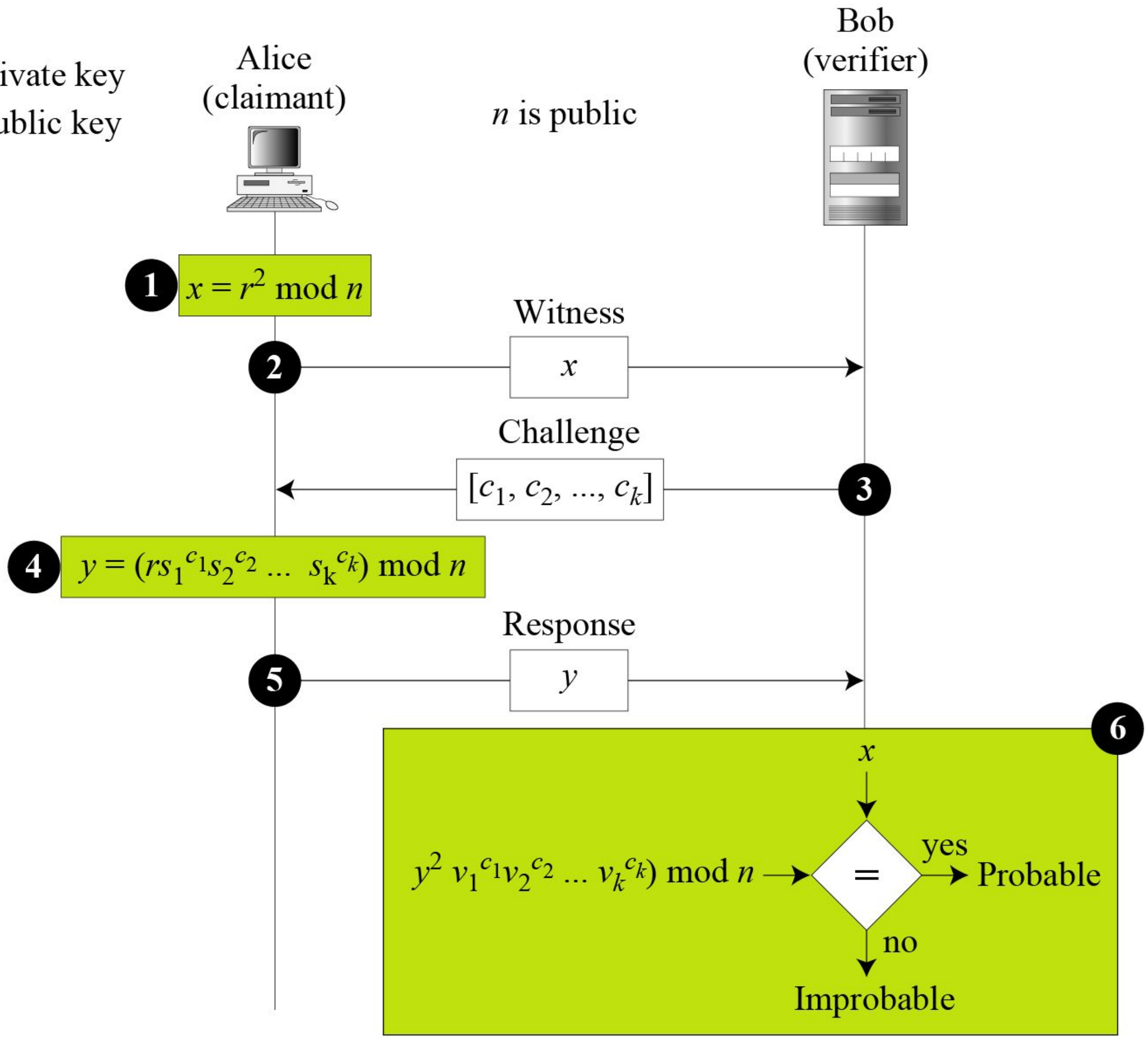
# 14.4.2 Feige-Fiat-Shamir Protocol

**Figure 14.15** *Feige-Fiat-Shamir protocol*

$[s_1, s_2, \ldots, s_k]$: Alice's private key

$[v_1, v_2, \ldots, v_k]$: Alice's public key

$r$: Random number



Alice (claimant)

Bob (verifier)

$n$ is public

1 $x = r^2 \bmod n$

Witness

2 $x$

Challenge

3 $[c_1, c_2, \ldots, c_k]$

4 $y = (rs_1^{c_1}s_2^{c_2} \ldots\ s_k^{c_k}) \bmod n$

Response

5 $y$

6 $x$

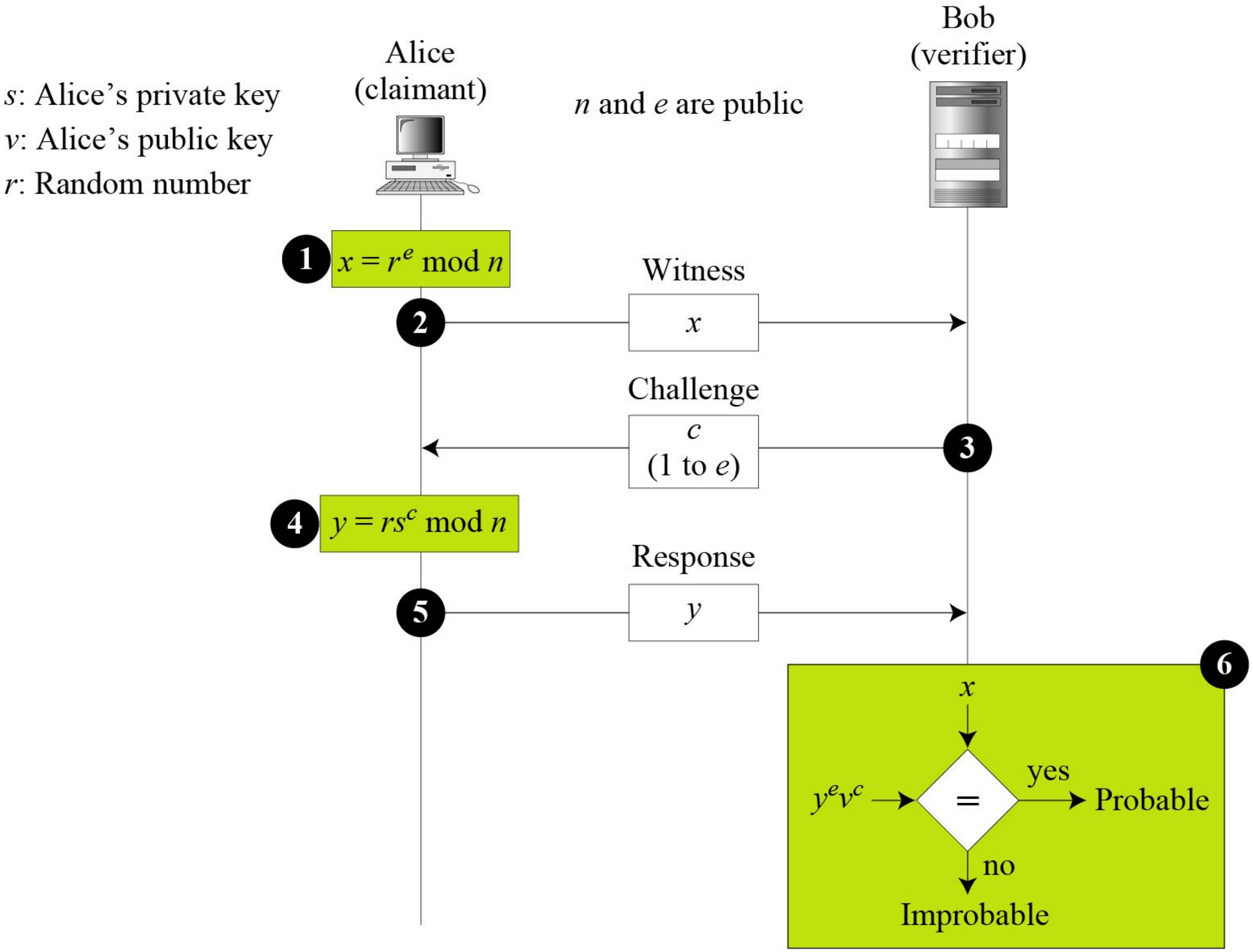
$y^2\ v_1^{c_1}v_2^{c_2} \ldots v_k^{c_k}) \bmod n$ → =

yes → Probable

no → Improbable

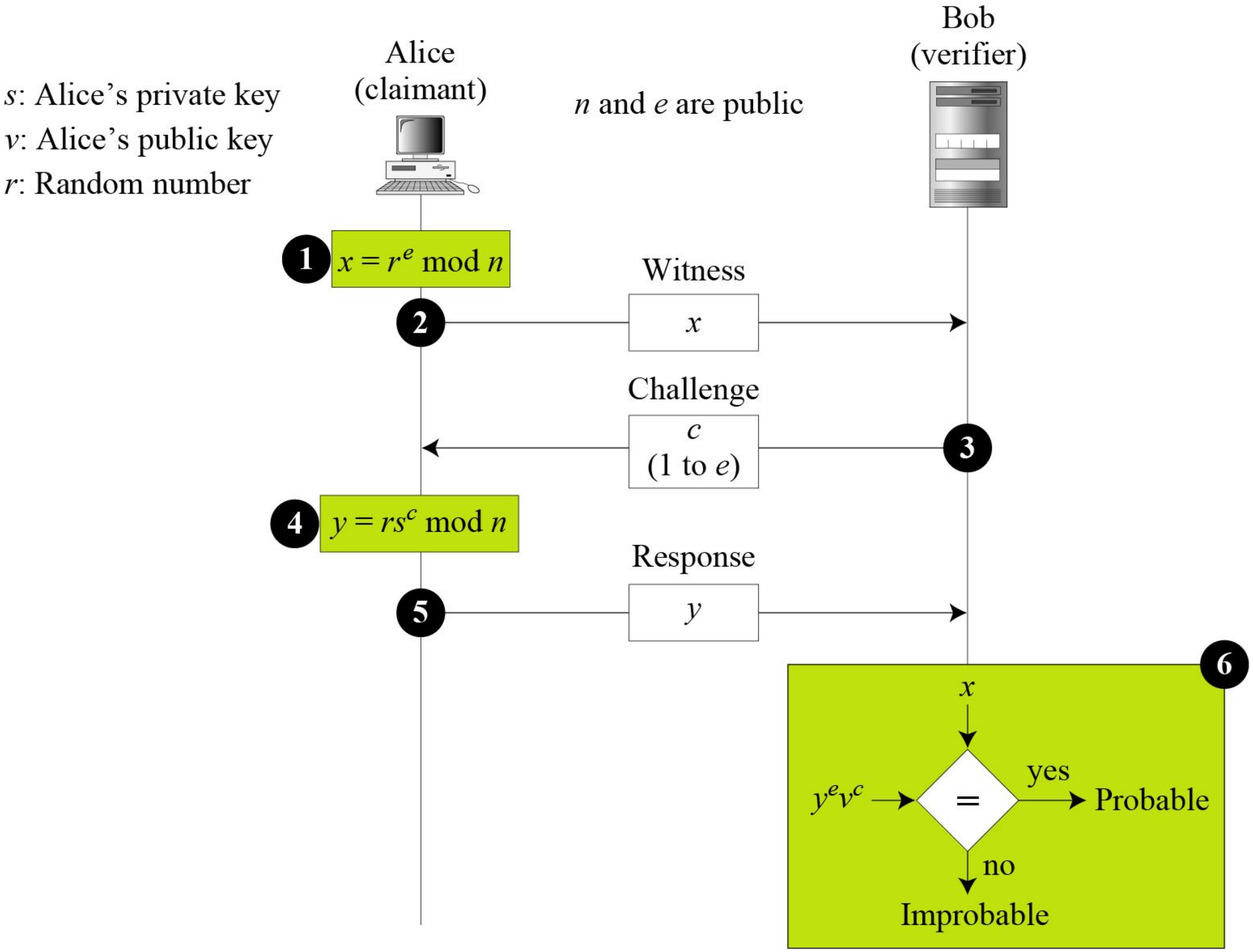
# 14.4.3 Guillou-Quisquater Protocol

## Figure 14.16 *Guillou-Quisquater protocol*



# *14.4.3 Continued*

## Figure 14.16 *Guillou-Quisquater protocol*



# 14-5 BIOMETRICS

***Biometrics is the measurement of physiological or behavioral features that identify a person (authentication by something inherent). Biometrics measures features that cannot be guessed, stolen, or shared.***

***Topics discussed in this section:***

**14.5.1 Components**
**14.5.2 Enrollment**
**14.5.3 Authentication**
**14.5.4 Techniques**
**14.5.5 Accuracy**
**14.5.6 Applications**

## *14.5.1 Components*

***Several components are needed for biometrics, including capturing devices, processors, and storage devices..***

## *14.5.2 Enrollment*

***Before using any biometric techniques for authentication, the corresponding feature of each person in the community should be available in the database. This is referred to as enrollment.***

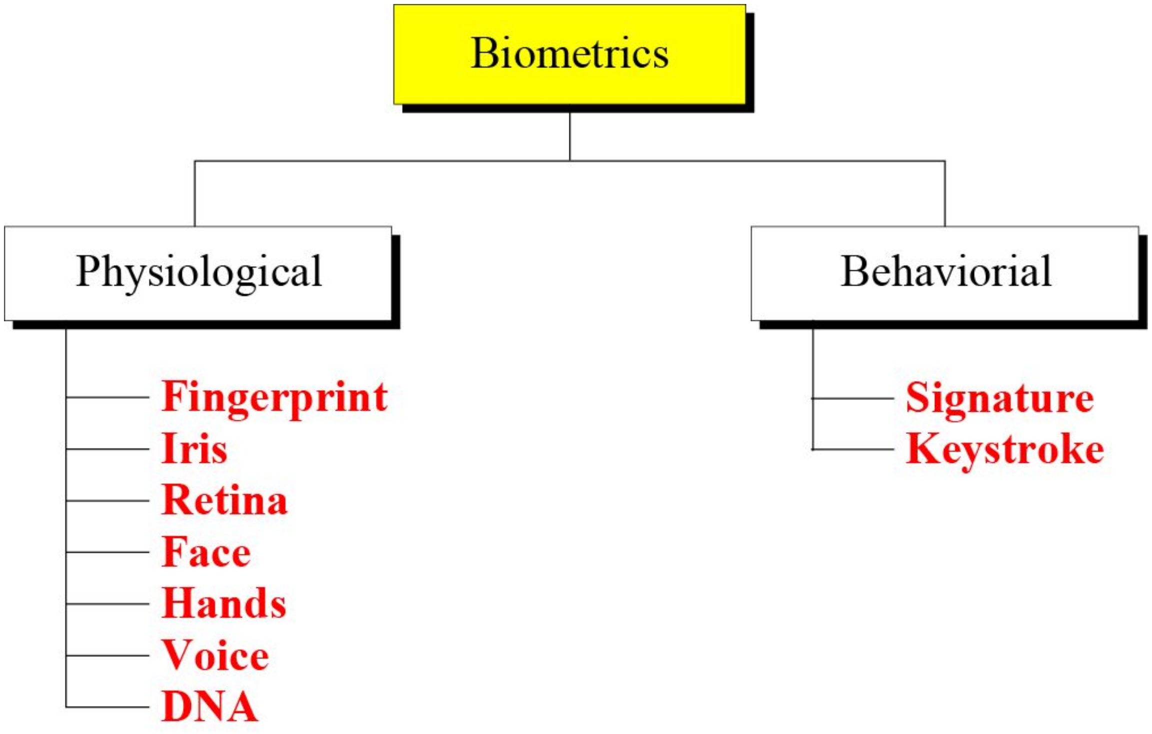
## *14.5.3 Authentication*

***Verification***

***Identification***

# 14.5.4 Techniques

**Figure 14.17** ***Techniques***



# *14.5.4 Continued*

## *Physiological Techniques*

- ***Fingerprint***
- ***Iris***
- ***Retina***
- ***Face***
- ***Hands***
- ***Voice***
- ***DNA***

# *14.5.4 Continued*

## *Behavioral Techniques*

***Signature***

***Keystroke***

# *14.5.5 Accuracy*

***False Rejection Rate (FRR)***

***False Acceptance Rate (FAR)***

# *14.5.6 Applications*

***Several applications of biometrics are already in use. In commercial environments, these include access to facilities, access to information systems, transaction at point-ofsales, and employee timekeeping. In the law enforcement system, they include investigations (using fingerprints or DNA) and forensic analysis. Border control and immigration control also use some biometric techniques.***